Effect of air humidification on the sick building syndrome and perceived indoor air quality in hospitals: a four month longitudinal study

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Abstract
The sensation of dryness and irritation is essential in the sick building syndrome (SBS), and such symptoms are common in both office and hospital employees. In Scandinavia, the indoor relative humidity in well ventilated buildings is usually in the range 10-35% in winter. The aim of this study was to evaluate the effect of steam air humidification on SBS and perceived air quality during the heating season. The study base consisted of a dynamic population of 104 hospital employees, working in four new and well ventilated geriatric hospital units in southern Sweden. Air humidification raised the relative air humidity to 40-45% in two units during a four months period, whereas the other two units served as controls with relative humidity from 25-35%. Symptoms and perceived indoor air quality were measured before and after the study period by a standardised self administered questionnaire. The technical measurements comprised room temperature, air humidity, static electricity, exhaust air flow, aerosols, microorganisms, and volatile organic compounds in the air. The most pronounced effect of the humidification was a significant decrease of the sensation of air dryness, static electricity, and airway symptoms. After four months of air humidification during the heating season, 24% reported a weekly sensation of dryness in humidified units, compared with 73% in controls. No significant changes in symptoms of SBS or perceived air quality over time were found in the control group. The room temperature in all units was between 21-23°C, and no significant effect of air humidification on the air concentration of aerosols or volatile organic compounds was found. No growth of microorganisms was found in the supply air ducts, and no legionella bacteria were found in the supply water of the humidifier. Air humidification, however, significantly reduced the measured personal exposure to static electricity. It is concluded that air humidification during the heating season in colder climates can decrease symptoms of SBS and perception of dry air.

(*Occup Environ Med* 1994;51:683-688)

Keywords: sick building syndrome, humidification, indoor air quality

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Accepted 16 May 1994

The sick building syndrome (SBS) involves non-specific symptoms such as irritation to the eyes, skin, and upper airways, headache, and fatigue.[1] In recent years, several epidemiological or experimental investigations on such symptoms have been published.[2-14] Various factors such as the age of the building,[2 3] the type of ventilation system,[4-6] room temperature,[7] static electricity,[8,9] volatile organic compounds,[3 8 10] and microbial growth[11] have been shown to influence the prevalence of symptoms of SBS. A sensation of dryness and irritation is essential in the SBS,[1] and such symptoms are common in both office[2 4 5 12] and hospital employees.[13] In Scandinavia, the indoor relative humidity is usually in the range of 10-35% during wintertime in workplaces,[8 14] and air humidification is rare.[8]

There is conflicting information in the scientific literature on the effects of air humidification. In experimental chamber studies with clean air, no significant relation between measured and perceived air humidity was found.[15 16] There may also be negative health aspects of air humidification. In a large study in Great Britain it was shown that buildings with air conditioning have a higher prevalence of SBS, the possible cause being microbial growth in humidifiers or chilling units.[5]

In contrast with these findings, controlled experimental field studies from Finland have showed beneficial effects of moderate air humidification during the heating season on the sensation of dryness and symptoms of SBS.[14 17] In one cross over study, steam air humidification relative humidity (of 30-40%) significantly reduced the prevalence of symptoms of SBS compared with no air humidification relative humidity (of 20-30%).[14] There are, however, few longitudinal studies available where the influence of air humidification on both symptoms and other indoor exposures has been studied.

Our study had two aims. The main aim of this study was to evaluate the effect of steam air humidification on SBS and perceived air quality during the heating season. The second aim was to study possible effects of air humidification on selected physical, chemical, and microbiological exposures in the buildings.

Material and methods

SUBJECTS

In an earlier survey (unpublished data), the age of the building and supply air flow was determined for all nine geriatric hospital units in one hospital district in southern Sweden. To increase the homogeneity of the study population, we selected the four newest and best ventilated hospital units situated in two hospitals for this investigation. At the beginning of the study in December 1991, 100 subjects were employed in these units. The subjects were invited to participate in the indoor climate investigation, but were not informed that it included air humidification in some departments. The study was restricted to those 90 employees who worked during the daytime and always in the same unit. The study base was dynamic, and was made up of employees working in the four selected departments during the study period (December 1991-April 1992). Steam air humidification was applied in two randomly selected units, one in each hospital during a four month period. The steam humidification was introduced in December 1991, after the first questionnaire was completed. The other two units, one in each hospital, served as controls. No type of air humidification had previously been used in any of the four departments.

ASSESSMENT OF SYMPTOMS AND PERCEIVED INDOOR AIR QUALITY

To evaluate the perception of symptoms of SBS and perceived indoor air quality (dry air, stuffy air, odour, and static electricity) the personnel were asked to answer a standardised self administered questionnaire. The questionnaire has been used in Sweden for some years, and most of the questions have been validated previously. The current version, with the designation MM-040-NA, was developed by the Department of Occupational Health in Örebro, Sweden.[18] It contains questions on perceived air quality, symptoms included in the SBS, personal factors, and the psychosocial climate at the workplace. A recall period of three months was used in the questionnaire. Work related symptoms were not assessed in the questionnaire. There was one question asking whether the respondents attributed perceived symptoms to indoor climatic factors. This information, however, was not used in this study, which covers symptoms regardless of the subjects' opinion on causes.

For each symptom or air quality perception, an answer could be given according to one of three options: "no, never", "yes, sometimes" and "yes, often". Often means every week. Each of the symptoms was assigned an index value, 2, 1, or 0, according to the answer. Twelve questions on medical symptoms, one on eye irritation, three on airway symptoms, three on dermal symptoms, and five on general symptoms were included in the questionnaire. The prevalence of subjects with at least one weekly symptom from eyes, airway, skin, or general symptoms was calculated. Also, an overall score of symptoms of SBS that ranged from 0 to 24 was constructed, by summing the individual symptom scores. Changes of symptoms or perceptions, ranging from −2 to 2, were calculated for each individual, by subtracting each index (0–2) at the beginning of the study period, from the score at the end of the period. The same questionnaire was distributed to all hospital employees before and after the study period. The subjects responded anonymously, and were instructed to answer all questions without paying any attention to the experience of indoor air quality expressed by colleagues.

ASSESSMENT OF PERSONAL FACTORS

Information on age, sex, job category, years of employment, numbers of working hours, smoking habits, hay fever, and asthmatic symptoms was obtained from the questionnaire. The current version of the questionnaire contained four questions covering different aspects of the psychosocial work conditions. The question that involved "interesting/stimulating work" measured work satisfaction. The question "too much work to do" covered work stress. The question "do you get help from your colleagues when you have a problem at work" measured the degree of social support, and the question on "opportunity to influence working conditions" measured the degree of personal influence experienced by the subjects. The questions on psychosocial conditions had four possible answers: "yes, often", "yes, sometimes", "no, seldom", and "no, never". Each of the variables was assigned an index value, 3, 2, 1, or 0 according to the answer; and a psychosocial dissatisfaction index was calculated by forming a total sum of the three indices (0–12).

ASSESSMENT OF EXPOSURE

The technical investigation comprised a building survey. Measurements of temperature, indoor air humidity, static electricity, exhaust air flow/person, microorganisms, volatile organic compounds, and particle concentration were performed by an experienced safety engineer. The room temperature, supply air temperature, exhaust air flow, and ventilation noise were measured to ensure that these conditions did not change during the study period. The other factors were measured to investigate if they were influenced by the air humidification.

In the building survey, information was gathered on the age of the building, the type of ventilation system used in it, the type of floor covering, signs of building dampness, and smoking restriction in the building. Information on work related exposures, including use of biocides, bulk dispensing of Ispagula, and use of gloves was also gathered.

Measurements of room temperature and relative air humidity were performed in one room in each unit during the whole four months period by a termohygrograph (CASELLA T 9420). Also, temperature was measured with a four channel instrument (MITEC MTM 20) every hour in one week in each unit, and recorded in a datalogger. The sites of measurement for the four channel instrument were outdoor air, supply air, and locations in two different rooms. Exhaust air flows were measured in each patients's room by a thermoanemometer (ALNOR GGA 65 P). The personal exposure to static electricity was measured by a field meter (EMF 57) coupled to a metal bracelet, and the charge was recorded on a pen plotter. The charge was measured during one minute of standardised walk by five test people in all units. The particle concentration was measured in the breathing zone and in the supply air ducts by a particle counter (NET 2000). This instrument registers particles within the range of 0·5–5 μm. In total, 40 three minute average measurements were performed.

Volatile organic compounds were sampled in one unit with humidification, and one control unit, on charcoal sorbent tubes (SKC-226-01). The air sampling rate was one l/min for over 90 minutes. The charcoal tubes were desorbed with 1 ml of carbon disulphide before analysis, which was performed by gas chromatography within two weeks from the sampling day.[8] Both the concentrations of 16 common compounds, and the total concentration of the identified and unidentified volatile organic compounds ($\mu g/m^3$) were calculated. Viable moulds and bacteria were analysed in settled dust from the ventilation ducts. Bacteria were cultivated on trypton glucose agar extract. Moulds were cultivated on malt agar. The number of colonies was counted, and compared in the laboratory with normal values for dust from ventilation ducts, obtained from the Swedish Building Research Institute.[19] Also, the water supplies of the humidification units were analysed for presence of legionella bacteria by the Microbiological Laboratory, University Hospital in Lund, Sweden.

All measuring instruments were calibrated before measurements were taken. The temperature instruments were calibrated before and during the measuring period by comparison with an accurate mercury thermometer. The termohygrograph was calibrated by comparison with a sling psychrometer. Temperature, relative humidity, volatile organic compounds, and particle concentration were measured 1·5 m above the floor, during the study period. No information on the result of the technical measurements was delivered to the hospital units before the questionnaire study was completed.

STATISTICAL METHODS

Differences in symptom index between the humidified group and controls at the beginning of the study period were determined by χ^2 analysis for 2 × 3 tables, or by the Mann-Whitney U test if the number in any of the cells was zero. For weekly symptoms, crude odds ratios (OR), with a 95% confidence interval (95% CI) were calculated. Also, multiple logistic regression was applied to calculated adjusted ORs. Differences in scores of changes in symptoms between exposed people and controls were analysed by Mann-Whitney U test. Differences in exposures between humidified and control units were analysed by Student's t test, or by Wilcoxon matched paired signed rank test. In all statistical analyses, two tailed tests and 5% level of significance were used.

Results

The response rate was 89%, both in the initial questionnaire and in the second study at the end of the study period. Due to changes of the dynamic population during the study period, however, a total number of 104 subjects participated in the study. Twenty four subjects responded in the first study only. Another twenty four subjects responded in the second study only, while 56 subjects participated in both studies. No significant differences in age or duration of employment were found between the units during the study period (table 1). The prevalence of current smokers was 45% in the humidified units, and 39% in the control units in December 1991. No significant difference in proportion of smokers, men, or job categories was found between the humidified and the control units during the study period. In the control units, however, the proportion of subjects with asthma or hayfever was significantly higher ($P < 0·05$, table 2).

BUILDING CHARACTERISTICS AND OCCUPATIONAL EXPOSURES

All hospital units were situated in small towns (5000–10 000 inhabitants), not near to heavy traffic or polluting industries. The age of the buildings ranged from five to eight years. All buildings were built of concrete or bricks, with slanting tile roofs, and sun protection devices above the windows, to minimise temperature variation. Two of the units had signs of dampness in the concrete floor, which was verified by humidity measurements. The floor coatings in all units consisted of polyvinyl chloride (PVC) material, and no wall to wall carpets were found. All buildings were equipped with mechanical ventilation with both supply and exhaust air (mixed system). The ventilation systems were equipped with rotary air to air heat exchangers without return air devices. The heating system was always water borne central heating with radiators, in combination with air heating by way

Table 1 Mean (SD) age and years of employment, in a dynamic population of hospital employees in two humidified two control units, before and after a four month study period

	Humidified units		*Control units*	
Characteristic	*December 1991 (n = 42)*	*April 1992 (n = 38)*	*December 1991 (n = 42)*	*April 1992 (n = 38)*
Age	39(12)	40(13)	36(10)	38(9)
Employment (y)	4·2(4·0)	3·9(2·8)	4·3(2·6)	5·6(5·7)

All results are NS.

Table 2 Selected demographic data (%) of a dynamic population of hospital employees in two humidified and two control units before and after a four month study period

	Humidified units		*Control units*	
Characteristic	*December 1991 (n = 42)*	*April 1992 (n = 38)*	*December 1991 (n = 42)*	*April 1992 (n = 38)*
Women	100	100	93	92
Current tobacco smoker	45	35	39	50
Asthma or hayfever*	17	13	43	31
Nurse	12	11	12	13
Auxiliary nurse	81	79	79	72
Other job category	7	10	9	15

*P < 0·05 Humidified v control units.

of the supply air. General smoking indoors was allowed in one humidified and one control unit, and restricted to certain rooms in the other two units. The cleaning procedures of the floors included daily mopping with water. No use of glutaraldehyde or other biocides, either as cleaning materials or in the air conditioning systems, occurred. Bulk dispensing of Ispagula was not used in any of the four departments, and the degree of use of latex gloves was similar in all units.

PHYSICAL MEASUREMENTS

As expected, the relative air humidity was significantly higher in the humidified departments (table 3): the relative humidity ranged from 35–45% in one and 40–45% in the other. In both control departments, the relative humidity ranged from 28–38%. Also, the air humidification resulted in a significant decrease in personal exposure to static electricity ($P < 0{\cdot}05$). The average indoor temperature during the day did not differ significantly between the humidified and the control units. The supply air temperature ranged from 21·0–22·0°C in all hospital units. No significant differences in degree of ventilation, or particle concentration in the air between the humidified and the control units were found.

Table 3 Temperature, air humidity, ventilation flow, static electricity, and air concentration of particles in two humidified and two control units

Variable	*Humidified units Arithmetic mean (range)*	*Control units Arithmetic mean (range)*
Room temperature (°C)	22·4(21·5–23·5)	21·7(20·5–23·0)
Relative air humidity (%)	40 (35–45)	31 (28–38)
Exhaust air flow (l/s/person)	14 (7–22)	14 (6–22)
Static electricity (V)	183 (25–400)	305 (50–500)*
Particles ($\mu m \cdot (10^3/f^3)$):		
0·5–0·7	29·9 (20–51)	29·8(19–53)
0·7–1·0	6·9 (2–13)	8·1 (2–17)
1·0–5·0	5·1 (1–11)	5·2 (1–12)
> 5·0	0·10(0·01–0·6)	0·07(0·01–0·2)

* $P < 0{\cdot}05$ By Wilcoxon matched paired signed rank test.

Table 4 Indoor concentration of volatile organic compounds ($\mu g/m^3$) in one humidified and one control unit

Compounds	*Humidified unit (n = 6) Arithmetic mean (range)*	*Control unit (n = 5) Arithmetic mean (range)*
Aromatics*	12 (3–29)	23 (4–63)
n-Alkanes†	3 (3-6)	4 (3-6)
Terpenes‡	5 (2-11)	6 (2-9)
Butanols§	7 (4–8)	5 (3–9)
2-etyl-1-hexanol	10 (6-17)	9 (1-12)
Unidentified low boiling compounds¶	46 (4–87)	52 (8–114)
Unidentified high boiling compounds‖	15 (11–21)	16 (13–19)
Total concentration of volatile organic compounds	97 (46–138)	116 (31–183)

* Sum of toluene, m-xylene, o-xylene, p-xylene, and ethylbenzene. †Sum of noctane, n-nonane, n-decane, and n-undecane. ‡Sum of α-pinene, β-carene, and limonene. §Sum of n-butanol and iso-butanol. ¶Sum of unidentified organic compounds with a retention time < n-dodecane. ‖Sum of unidentified organic compounds with a retention time ⩾ n-dodecane

Table 5 Changes of indoor climate perceptions among employees in two humidified hospital units (n = 30) and two control units (n = 26) during a four month study period*

	Humidified units (incidence (%) of)		*Control units (incidence (%) of)*		
Type of perception	*Decreased† perception*	*Increased‡ perception*	*Decreased† perception*	*Increased‡ perception*	*P-value§*
Draught	11	54	4	30	NS
Variable temperature	17	26	42	17	NS
Too high temperature	33	11	22	13	NS
Too low temperature	22	44	25	33	NS
Stuffy "bad" air	25	18	28	20	NS
Dry air	62	0	21	13	< 0·01
Unpleasant odour	22	15	32	20	NS
Static electricity	27	8	4	21	< 0·05
Passive smoking	7	15	4	28	NS
Noise	28	14	12	8	NS
Inadequate light	37	33	32	28	NS
Dustiness	24	17	29	17	NS

* Calculated as difference in perception index (0–2) before and after the study period.
†Proportion of subjects (%) with a negative value of perception change (range −2 to 2).
‡Proportion of subjects (%) with a positive value of perception change (range −2 to 2).
§Test for difference in perception change in humidified, compared with control units, by Mann-Whitney U-test.

CHEMICAL AND BIOLOGICAL MEASUREMENTS

Volatile organic compounds in the breathing zone were measured in the two hospital units with increased moisture content in the concrete floor. Table 4 shows that 2-ethyl-1-hexanol was detected in all rooms, but no significant differences in the chemical composition of the air between the humidified and the control unit were found. The biological investigations showed that no viable moulds or bacteria were present in dust from the supply air ducts in any of the units. No legionella bacteria were found in the supply water of the humidification systems.

PERCEPTION OF INDOOR AIR QUALITY

In December 1991, before air humidification, no significant differences in any type of perception between the control units and the humidified units, were found. The most prevalent discomforts in all four units were complaints on dry air, static electricity, and stuffy air. On average, 73% of the 84 responders in 1991 reported weekly sensations of air dryness, 39% perceived static electricity every week, and 35% reported weekly perceptions of stuffy air.

Humidification greatly affected the perception of dry air and static electricity. In April 1992, after four months of air humidification, the prevalence of weekly complaints of dry air was 24% in the humidified group (n = 38), but still 73% in the controls (n = 38) (OR = 0·1; 95%CI 0·04–0·3, $P < 0{\cdot}001$). Weekly complaints on static electricity were reported by 26% in the humidified group, compared with a 55% prevalence in controls (OR = 0·3; 95% CI 0·1–0·8, $P < 0{\cdot}05$). The reductions of these discomforts were similar in both humidified departments. No significant difference for other types of perception of air quality were found in April 1992. Similar results were obtained if the analysis was restricted to those 56 subjects who responded both in December 1992 and April 1992. The incidence of both reduced and increased perceptions were high for many complaints about physical factors such as draught, temperature, and inadequate light, suggesting that perceptions of indoor climate may have large normal fluctuations. Despite these fluctuations, significant differences between humidified units and controls were found for both the change of sensation of air dryness ($P < 0{\cdot}01$) and static electricity ($P < 0{\cdot}05$, table 5).

SICK BUILDING SYNDROME

No significant differences in any symptom

Table 6 Adjusted ORs for weekly symptom (0–1) among employees in two units exposed to air humidification and two control units before and after a four month study period*

	Type symptom			
	Eye†	Airway‡	Dermal§	General¶
Before humidification:				
Symptom prevalence (%) in				
Pre-exposed (n = 42)	35	35	46	35
Controls (n = 42)	21	32	32	38
Crude OR (95% CI)	2·0(0·7–5·3)	1·2(0·5–3·0)	1·8(0·7–4·6)	0·9(0·3–2·2)
Adjusted OR‖ (95% CI)	1·4(0·4–4·5)	1·4(0·4–4·9)	2·8(0·8–9·8)	1·1(0·3–3·6)
After humidification:				
Symptom prevalence (%) in:				
Post-exposed (n = 38)	19	11	39	32
Controls (n = 38)	28	39	36	27
Crude OR (95% CI)	0·6(0·2–1·8)	0·2(0·06–0·6)	1·1(0·4–2·9)	1·3(0·5–3·6)
Adjusted OR‖ (95% CI)	0·5(0·1–1·9)	0·2(0·04–0·7)	1·5(0·5–5·1)	1·3(0·4–4·5)

* At least one weekly symptom from each symptom group.
†Itching, burning, or irritation in the eyes.
‡Irritated, stuffy or running nose, hoarse or dry throat, or cough.
§Dry facial skin, itch in the scalp or ears, or dry skin on the hands.
¶General fatigue, feeling heavy-headed, headache, nausea, dizziness, or difficulties in concentrating.
‖Exposed *v* controls, adjusted by multiple logistic regression for differences in age, sex, atopy, smoking habits, employment time, type of occupation, and psychosocial work climate.

scores were found between the control units and the experimental units in December 1991, before air humidification. The prevalence of weekly symptoms was high in all units. The average prevalence in all subjects (n = 84) were 28% for eye symptoms, 34% for airway symptoms, 39% for dermal symptoms, and 37% for general symptoms. No significant differences between experimental and control subjects were found in 1991 (table 6).

In April 1992, the prevalence of airway symptoms was significancy lower ($P < 0·001$) in humidified units than in the control units (adjusted OR = 0·2; 95% CI 0·04–0·7, table 6). For other weekly symptoms, no significant differences were found in April 1992. When analysing changes of scores of symptoms among subjects responding both times (n = 56), similar results were obtained. The humidified units reported a significant reduction in the score for throat dryness compared with changes in controls ($P < 0·001$). A borderline significance was also found for the reduction of mental fatigue ($P = 0·05$) and cough ($P = 0·05$, table 7). No significant

Table 7 Changes of symptoms among employees in two humidified hospital units (n = 30) and two control units (n = 26) during a four month study period*

	Humidified units (incidence (%) of)		Control units (incidence (%) of)		
Type of symptom	Decreased† symptom	Increased‡ symptom	Decreased† symptom	Increased‡ symptom	P-value§
General fatigue	20	13	35	8	NS
Feeling heavy-headed (mental fatigue)	34	7	12	16	0·05
Headache	24	14	26	17	NS
Nausea or dizziness	18	4	8	19	NS
Difficulties in concentrating	14	14	15	12	NS
Itching, burning, or irritation of the eyes	29	7	12	11	NS
Irritated, stuffy, or runny nose	20	10	12	16	NS
Hoarse, dry throat	61	4	16	32	< 0·001
Cough	28	4	17	25	0·05
Dry facial skin	21	10	19	15	NS
Itch of scalp or ears	7	14	12	12	NS
Dry skin on the hands	11	18	16	36	NS

* Calculated as difference in symptom index (0–2) before and after the study period.
†Proportion of subjects (%) with a negative value of symptom change (range −2 to 2).
‡Proportion of subjects (%) with a positive value of symptom change (range −2 to 2).
§Test for difference in symptom change in humidified, compared with control units, by Mann-Whitney U-test.

effect of air humidification on the change of the overall score for SBS symptoms, incidence of asthma, or the psychosocial score, were detected in those 56 subjects responding both times. The overall incidence of new asthmatic symptoms was 4%, and the incidence of disappearance of asthma symptoms was 16%.

Discussion

This experimental study has shown that air humidification up to a relative humidity of 40–45% decreases the perception of dry air and malodour. Also, air humidification reduced the prevalence of symptoms compatible with the SBS.

Many problems are inherited in a cross sectional epidemiological study, particularly if the studied phenomena have a multifactorial cause. Some of these problems can be reduced if an experimental and longitudinal design is selected. A selection bias can occur, both because of an incorrect study design and as a result of a low response rate. This study was designed to include the four newest geriatric hospital units within one geographical area, and the humidification exposure was randomly distributed in two of the units, while the other two served as controls. Also, the participation rate was high. Because of the dynamic population structure, changes of subjects during the study period could have influenced the results. When applying paired comparisons, however, similar results for the dynamic population were obtained. Thus it is less likely that selection bias had any important influence on the result of our study.

Another problem of validity is response bias due to the awareness of the exposure. In this study, however, no information on the purpose of the study was given to the participants during the study period. Also, the results of the measurements or the questionnaire study were not reported to the units until the questionnaire investigation was completed. Only specific exposures and perceptions were related to air humidification. Finally, in studies where multiple effects of exposure are analysed, mass significance may influence the results. In our study, however, most results were significant and < 1% level, and the total pattern of the results was consistent with the hypothesis. We do not think that the internal validity of our results have been unduly affected by multiple statistical tests, response bias or selection bias.

The perception of poor indoor air quality, particularly air dryness and irritation is essential in the SBS as defined by a working group of the World Health Organisation.[1] This syndrome comprises irritative symptoms from eyes, skin, and upper airways as well as general symptoms, including headache and fatigue. Other investigators have mainly studied complaints in office workers. In the Danish Town Hall Study,[2] 52% of the women complained of dry air and 16% complained of static electricity. Similar figures were obtained in a study from northern Sweden,[12] where 43% of the women complained of dry air.

There are, however, indications that symptoms of SBS are common also in hospital workers.[9 13]

Common complaints in our study were dry air and static electricity. We showed that these perceptions were drastically reduced even with moderate air humidification. Also, a significant decrease of airway symptoms, particularly throat dryness, was found. Our results agree with other recent studies from Finland,[14 17] Sweden,[13] and the United Kingdom.[20] In one crossover experimental field study, steam air humidification (relative humidity of 30–40%) significantly reduced the prevalence of symptoms of dryness compared with no air humidification (relative humidity of 20–30%).[14] In another experimental study in a large office building, humidification (relative humidity of 45–55%) significantly reduced the prevalence of skin and airway symptoms and perception of dry air compared with no air humidification (relative humidity of 10–20%).[17] Similar results were obtained in an experimental field study in a Swedish hospital with indoor air complaints.[13] Finally, in a non-experimental longitudinal study from the United Kingdom, higher air humidity was associated with less symptoms.[20] There are also indications that air humidification may result in a decrease of sickness absence in office workers.[21]

Our results do not contradict other studies where adverse health effects due to microbial growth in humidifiers or air conditioning units have been found.[5 22] These studies show the importance of avoiding spread or growth of airborne microorganisms indoors, and therefore a moderate steam humidification under safe conditions is the best choice. It is still unclear which mechanisms are involved in the reduction of symptoms, air dryness, and malodour in humidified buildings, but it has been recommended that the relative humidity should be between 40 and 60%.[23] The possible influence of air humidification on air quality seems not to have been measured in most other experimental field studies. We found no effect of air humidification on the concentration of volatile organic compounds or particles, but a significant reduction of measured static electricity. Our results indicate that further research is needed to understand the mechanism of the positive health effects of air humidification in Nordic countries, where air humidity can be extremely low during cold winters.

This study was supported by grants from the National Swedish Institute for Building Research, and the County Council of Malmöhus.

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